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Modern Surgery - Chapter 3. Inflammation

John Chalmers Da Costa
Jefferson Medical College

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III. INFLAMMATION.

Definition.—When the tissues are injured they react or respond, and this reaction or response is known as inflammation. The process of inflammation is defined by Professor Burdon-Sanderson as “the succession of changes which occur in a living tissue when it is injured, provided that the injury is not of such a degree as at once to destroy its structure and vitality.” Professor Adami, in his article upon inflammation in Allbutt’s “System of Medicine,” points out that this definition really includes too much. He alludes to the hemorrhage which occurs in the liver after a traumatism, and the subsequent changes in the extravasated corpuscles, and points out that these changes are not inflammatory phenomena. This definition, however, includes all inflammatory conditions, is largely employed, is very useful, indicates the cause, and, as Burdon-Sanderson says, makes clear that inflammation is a process and not a state (Adami). Adami’s definition is as follows: “The series of changes constituting the local manifestation of the attempt at repair of actual or referred injury to a part, or, briefly, the local attempt at repair of actual or referred injury.” The changes alluded to in Burdon-Sanderson’s definition comprise (1) changes in the vessels and the circulation, (2) departure of fluids and solids from the vessels, and (3) changes in the perivascular tissues.

Vascular and circulatory changes were formerly thought to be absolutely essential to inflammation in both vascular and non-vascular tissues. In the former they occur in the inflamed tissues; in the latter (cornea and cartilage) they are manifest in neighboring tissues from which the non-vascular area derives its nutritive material. As a matter of fact, in inflammation, vascular changes are almost always present; but in a rather trivial corneal inflammation the episcleral vessels may not dilate, and the only white corpuscles which gather in the damaged area are those which come from the lymph-spaces of the cornea. Inflammation in any tissue will not be accompanied by vascular dilatation unless the process reaches a certain stage of severity.

Active Hyperemia.—When an irritant is applied to tissue there may be a momentary arterial contraction due to irritation of the nerves, but this contraction is transitory, and is not an inflammatory phenomenon. The first vascular phenomenon is dilatation of all the vessels,—capillaries, venules, and arterioles,—appearing first and being most pronounced in the small arteries. As a result of the dilatation there are increased rapidity of circulation and increased determination of blood to the part, and the area of hyperemia becomes warmer than is normal. This condition of increased circulatory activity is known as “active hyperemia” (Fig. 25).

Active hyperemia is an increase in the amount of moving blood in a part. Passive hyperemia is an increase in the amount of blood in a part, but not of moving blood, as passive hyperemia or congestion is due to venous obstruction, and the blood is stagnated. Diminution in the amount of blood in a part is ischemia. Local anemia is the complete cutting-off of the blood-supply of a part.

In active hyperemia more blood goes to the part and more blood passes through it, an increased amount of venous blood comes from the hyperemic area, the venous tension is increased, and the veins may even pulsate. The

capillaries, which under ordinary circumstances contain but few blood-cells (Fig. 24), become filled with corpuscles (Fig. 25), and even the smallest capillaries pulsate. The blood in the veins adjacent to the area of inflammation is of a much lighter red than in health. Many capillaries which were invisible

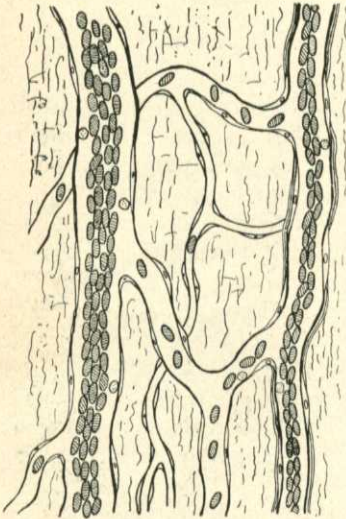


Fig. 24.—Normal vessels and blood-stream.

under normal conditions become visible when active hyperemia exists. The capillaries contain no muscle-fiber, and hence these tubes cannot actively contract, except so far as the caliber of the tubes is altered by the contraction or expansion of the endothelial cells of the capillary wall. Contraction and dilatation of the capillaries depend chiefly upon the amount of blood sent to or retained in them. In active hyperemia the increased amount of blood sent to the part causes capillary dilatation. As a result of the dilatation the endothelial cells become thinner than before, the cells as a result of irritation lose some of their power to restrain exudation, and some observers assert that openings are formed between the cells or that previously existing openings enlarge. Fluid elements rarely leave the blood-vessels during active hyperemia, but they

occasionally do. The wheals of urticaria are thus formed (Warren). Active hyperemia is often the first stage of an inflammation, but it is not of necessity followed by other inflammatory changes, and it can be caused by nerve section or nerve stimulation.

The duration of active hyperemia is variable. If the irritation was brief, the hyperemia is very transitory. If the irritation is prolonged, it may last some time before giving way to retardation. In the web of a frog's foot, if an irritant is applied, hyperemia lasts from one-half hour to two hours before it is replaced by retardation.

Clinical Signs of Active Hyperemia.—A hyperemic part, if on or near the surface, is red in color, imparts a sense of heat to the examining hand, the color quickly disappears on pressure and quickly returns when pressure is released. In a congested part the temperature is diminished, the surface is purple, the congested veins are visible, there are edema and a sensation of coldness and numbness. When congestion is purely local, the lividity disappears quickly when pressure is applied and returns quickly when pressure is removed. When due to disease of the heart or lungs, it disappears and returns slowly. When a local congestion is about to give way to gangrene, the lividity disappears very slowly on pressure and crawls back slowly when pressure is released.

Retardation.—After active hyperemia has existed for a variable time the blood-current begins to lessen in velocity, until it becomes more tardy than in health. This is known as "retardation of the circulation." Retardation is first noted in the venules, next in the capillaries, and last in the arterioles;

but arterial pulsation continues. The red cells take the center of the blood-stream, which is known as the axial current. The white corpuscles drop out of the central stream, separate from the red, and float lazily along near the vessel-wall, and they are accompanied by many third corpuscles. The white cells show a strong tendency to adhere to the venule-walls, and, as a result, accumulate against the inside of, and stick to, these walls and to one another, until the venules are entirely lined with layers of *leukocytes* (Fig. 25). The third corpuscles act in a similar manner and take the peripheral current. In the capillaries some leukocytes gather, but not many. In the arterioles they adhere during cardiac dilatation, but are swept away by the force of the heart's contractions. Retardation is believed to be chiefly due to paresis of the muscular walls of the arterioles. This causation seems probable when we recall Lord Lister's experiments upon the pigment-cells of the frog's foot. Lister proved that inflammation paralyzes the pigment-cells, and concluded that dilatation at the focus of an inflammation is due to the paralyzing action of an irritant. Dilatation at a distance from the focus is a reflex phenomenon (W. Watson Cheyne). When the vessels are weakened or paralyzed, the contractions of the arterioles are feeble or absent, and the blood is no longer urged forward by arterial power. The endothelial cells of the small vessels enlarge distinctly and develop a condition of stickiness, which leads the white cells to adhere to them, and thus increases resistance to the current of blood and adds to retardation. Fluids pass through a vessel in this condition more readily than a healthy vessel, and white corpuscles leave the vessel in large numbers.

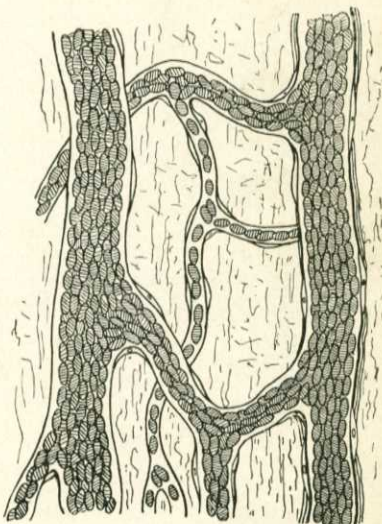


Fig. 25.—Dilatation of the vessels in inflammation.

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Oscillation and Stagnation.—By this accumulation of leukocytes the blood-stream is progressively narrowed and the axial current is impeded. The red blood-cells begin to stick to one another, forming aggregations like *rouleaux* of coin, which masses increase the difficulty the axial current has to contend with, until progressive movement ceases and the contents of the vessels sway to and fro with each heart-beat. This is the stage of *oscillation*. In a short time oscillation ceases and the vessels are filled with blood which does not move, and the vessel-walls become irregular in outline or even pouched. This stage is known as “stasis” or “stagnation” (Fig. 26). If stasis persists, coagulation occurs, because the vessel-walls have been so injured by the irritant as to be practically dead material, and they are no longer able to prevent clotting of their contents. Stasis is chiefly due to paralysis and damage of the vessel-walls. Migration ceases when stasis takes place. We can then sum up the vascular changes of inflammation by stating that they consist in a dilatation of the small vessels and a primary acceleration, a secondary retarda-

tion, and a subsequent stagnation of the blood-current with adhesion of leukocytes to the walls of veins and capillaries, migration of leukocytes, and the aggregation into masses of the red blood-cells. If stasis persists, the vessel-walls become profoundly involved in the inflammatory change, and they may rupture or be completely destroyed.

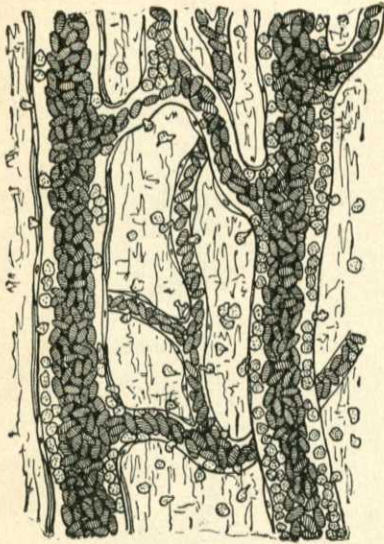


Fig. 26.—Retardation of blood and migration of white corpuscles in inflammation.

Exudation of Fluids.—It is to be remembered that in the process of nutrition serum and even white cells pass into the tissues through the walls of veins and capillaries. Whenever retardation of the circulation arises, there is an increase in the amount of plasma which passes out of the vessels, but in inflammation the exudation is vastly greater in amount and is different in composition. In a slight inflammation, and in the early stage of any inflammation, there is an increase in the fluid exudate, and we speak of the condition as “serous inflammation.” This fluid is really not serum, but is liquor sanguinis. We find true serum in passive congestion, not in active inflam-

mation. The fluid in a serous exudation contains very few white cells, and hence little or no fibrin can form in it, and coagulation does not take place in the perivascular tissues; and if the inflammation goes no further, the exudate is absorbed by the lymphatics. A blister is an example of serous inflammation. If the inflammation continues to intensify, the exudation is altered in character—it becomes thicker, turbid, and very coagulable. It contains many white cells and fibrin elements, and coagulates in the tissues, because some of the leukocytes break up and set free fibrin ferment, and fibrin ferment causes the union of calcium and fibrinogen and the formation of fibrin. This fluid is known as “lymph,” or plastic exudation, and when it is present we speak of the condition as “plastic inflammation.” The lymphatics endeavor to absorb the fluid, but become occluded by coagulation, and the area they drain becomes swollen, hard, and “brawny.” Lymph can be seen in the anterior chamber of the eye in cases of plastic iritis. The slighter the inflammation, the less albuminous is the fluid; the more intense the inflammation, the more albuminous is the fluid. The focus of an inflammation usually feels brawny because of coagulation of a highly albuminous exudate; the periphery of an inflammation is soft and edematous because of the presence there of thin and non-coagulable exudate. Inflammatory lymph contains proteids and other substances. “Of these the more important are ferments, the results of proteolysis (notably fibrin and its precursors and peptones), and in many cases mucin, together with bactericidal substances, and, where bacteria are present, the products of their growth.”* The amount of the

* Adami, in Allbutt's “System of Medicine.”

exudation varies with the violence of the irritation, the nature of the irritant, the general condition of the organism, and the state of the tissues which are involved. In dense tissue (bone, periosteum, etc.) the exudation is scanty. In loose tissues (subcutaneous tissue) it is profuse. Profuse exudation may take place into a joint, the pleural sac, the peritoneal cavity, or the pericardium.

Does the plasma leave the vessels as a simple filtrate? Some maintain that it does. Heidenhain and others claim that it does not, and believe that the endothelial cells play an active part in the process. Heidenhain likens exudation to secretion, because some materials from the plasma pass out and others do not. Adami is inclined to agree with Heidenhain, that the epithelium plays "not a passive, but an active rôle." It is a question if open spaces do or do not exist between the endothelial cells, but the existence of such spaces has not been proved.

Migration and Diapedesis.—Even early in an inflammation some few white corpuscles pass through the vessel-walls; but when the inflammation is well established, large numbers, and when it is severe vast hordes, pass into

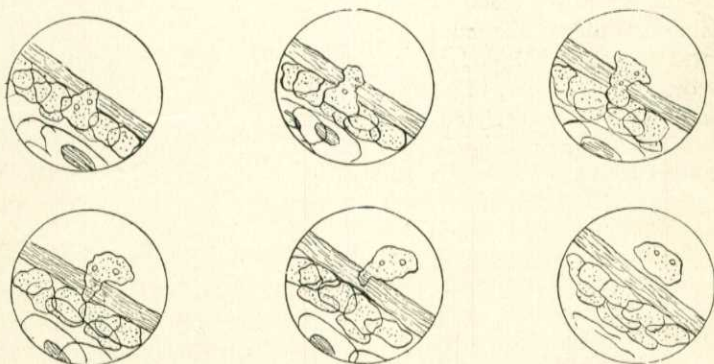


Fig. 27.—Stages of the migration of a single white blood-corpuscle through the wall of a vein (Caton).

the perivascular tissues. This process is known as "migration" (Fig. 27). The leukocytes throw out protoplasmic arms, insert themselves between the cells of the walls of the vessel, and pull themselves through by their power of ameboid movement (Fig. 28). Most observers claim that they do not pass through existing open doors, but form openings which close after them. This is readily accomplished, because the vessel-wall is itself damaged, weakened, and convoluted. Others claim that stomata exist between the endothelial cells, the vessel-wall being porous like a filter. The escape of leukocytes takes place chiefly from the venules, though some migrate through the capillaries and even the arterioles (Fig. 27).

The leukocytes are influenced to move toward the damaged tissue by the attractive force known as positive "chemiotaxis," a force which draws them toward invading bacteria, to regions of irritation, and to areas of tissue death. Leukocytes may move from very virulent organisms, influenced by what is known as negative "chemiotaxis." The migration of a leukocyte requires

but a short time. Fig. 27 shows the migration of a white blood-cell through a vein-wall, the process requiring one hour and fifty minutes. In very acute inflammations red corpuscles pass into the tissues. Red corpuscles are not capable of ameboid movements, and they escape through damaged areas in

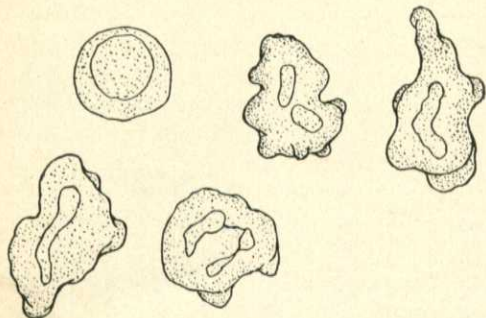


Fig. 28.—Ameboid movements of a leukocyte (Warner).

the capillary walls, the process being a passive one on the part of the corpuscles. The escape of corpuscles by a passive process is known as "diapedesis," in contradistinction to the escape of leukocytes by active ameboid movements, a process known as "migration." The white corpuscles usually greatly increase in number in the blood of a person who has an acute inflammation

(leukocytosis), and the blood-making organs, such as the spleen and lymphatic glands, are often enlarged.

Blood Plaques.—Blood plates or blood plaques may be discovered in freshly drawn blood, but, unless they are present in unusual numbers, they will rarely be seen in specimens prepared in the usual way. The third corpuscles can be seen by a high power microscope in the moving blood of the web of a frog's foot. In blood outside of the body they are destroyed as soon as coagulation begins, and in order to see them coagulation must be prevented. Some observers maintain that the third corpuscles are the real fibrin-formers. The blood plaques, or third corpuscles, are found to be present in increased numbers in inflammation. In health their usual proportion to red cells is as 1 to 20. They are especially numerous at the height of fever processes and during convalescence from an extensive abscess.

Changes in the Perivascular Tissues.—The liquor sanguinis which exudes during an acute inflammation coagulates unless prevented by virulent bacteria. It has often been asserted that exudation is Nature's method of supplying nutriment to the cells of the damaged region. Adami points out the apparently contradictory observation that the amount of exudate is in direct proportion to the rapidity of cell-destruction, but nevertheless concludes that exudation stands in close relation with cell-proliferation.* From whatever cause, tissue-cells multiply, and this process is known as "cell-proliferation."

When a tissue is injured it inflames, and, as Adami points out, the reaction is an attempt to repair injury.

Irritation may lead to degeneration and death of cells; it may lead to growth and multiplication. In many cases both processes are active in the acute stage, the cells at the focus of the inflammation undergoing degeneration and destruction, and those at the boundary undergoing growth and proliferation.†

* Adami, in Allbutt's "System of Medicine."

† Allbutt's "System of Medicine."

If tissue-cells have been seriously damaged, they perish, and new cells are required to replace them. The inflammatory process has led to exudation of plasma and migration of leukocytes into the perivascular tissues. The connective-tissue cells multiply and produce young cells, which are known as "fibroblasts," and which eat up many leukocytes. The migrated leukocytes in part surround the inflamed region and retard diffusion of the process. Many enter the diseased area and attack bacteria. Some undergo degenerative changes and liberate fibrin ferment which makes the exudate clot. Some move out of the inflamed area, each one carrying within it tissue débris, and many are eaten up by the fibroblasts. There is no real proof that leukocytes proliferate and help directly to form new tissue. This mass of young cells, taking origin from the fixed cells, has been called embryonic tissue, because of a fancied resemblance to the cells of the embryo. It has also been called indifferent tissue, because of the belief that it could be converted indifferently into various tissue according to circumstances. It is also spoken of as inflammatory new formation.

An exudation may be absorbed by the lymphatics. It may be converted into pus if infected with pyogenic bacteria, or be replaced by cells from the proliferation of fixed tissue-cells, the cellular mass being subsequently vascularized by the extension into it of capillary loops derived from adjacent capillaries. When embryonic tissue is filled with blood-vessels,—that is to say, when it is vascularized,—it is called *granulation tissue*. Granulation tissue is finally converted into fibrous tissue. The above complicated processes, vascular and perivascular, are not accidents nor haphazard freaks, but are Nature's efforts to bring about a cure.

Dilatation is due to the direct effect of the irritant upon the muscle or its nerve-elements. Retardation and stasis are due to paralysis of the vessel-wall, which paralysis causes resistance to the passage of the blood-stream and adhesion of the leukocytes to the vessel-wall. The blood-liquor exudes and the leukocytes migrate. Often these efforts of Nature succeed. Acceleration of the circulation may succeed in washing away an irritant from the vessel-wall. By bringing quantities of blood to the part it secures copious exudation of plasma. The exudation may wash away and remove irritants from the tissues, and the germicidal blood-liquor may destroy bacteria in the damaged area. The migration of corpuscles may prove of great service. The leukocytes surround an area of infection and tend to limit its spread. Leukocytes have phagocytic properties, and energetically attack and often destroy bacteria, and they furnish antitoxins which antagonize and may neutralize the poisons produced by micro-organisms. Leukocytes aid in separating dead tissue from living, and remove tissue débris from the area of inflammation. The multiplication of the fixed connective-tissue cells leads to the formation of fibroblasts, and fibroblasts are converted into fibrous tissue, which effects permanent repair (these changes will be alluded to again in the section on Repair).

Nature may fail in her efforts. For instance, an enormous exudate increases stasis and may cause such tension that gangrene results.

Inflammation in Non-vascular Tissue.—A type of non-vascular tissue is the cornea, and the cornea can inflame. The healthy cornea contains no blood-vessels. It is formed of many layers of fibers, each layer running

parallel with the corneal surface and forming angles with the fibers of the adjacent layers. Between the layers are communicating lymph-spaces containing connective-tissue cells known as corneal corpuscles. It obtains its nourishment in part from the vessels of the conjunctiva, but chiefly from the vessels of the ciliary body and sclera. When the cornea inflames, the episcleral, conjunctival, and ciliary vessels usually dilate and pour out exudate, and the fluid exudate and the leukocytes enter into the corneal lymph-spaces. The exudate coagulates and cell-multiplication ensues as in any other inflammation. In mild inflammations the vessels about the cornea may not dilate. Leukocytes, from the lymph-spaces, reach the seat of injury in small numbers, and the fixed cells multiply. Nancrede points out that in trivial inflammation which injures but does not destroy the epithelium leukocytes may not go to the seat of inflammation, the only change being enlargement and multiplication of corneal corpuscles. If new formation takes place, a permanent opacity mars the cornea as a consequence.

Cartilage has no blood-vessels; neither has it spaces, like the cornea, for a free circulation of lymph. Inflammation can occur in cartilage, but it is always slow in evolution and prolonged. Cartilage is nourished by a flow of plasma between the cells, but there is no direct connection with blood-vessels. The plasma is furnished by the vessels at the margin of the perichondrium. When inflammation occurs, the cartilage cells enlarge and their nuclei proliferate, the intercellular substance softens and cartilage cells may be cast off. After a long time vessels may invade the inflamed cartilage and fibrous tissue form from the perichondrium, but in some cases a loss of substance is not repaired.

Inflammation of Mucous Membrane.—It may be catarrhal, suppurative, croupous, or diphtheritic. In a *catarrhal inflammation* the increased blood-supply causes an excessive flow of mucus. The submucous tissues present the ordinary changes of inflammation and quantities of epithelial cells are cast off from the surface. Fibrous tissue may form in the submucous tissue and thus cause permanent thickening (strictures, etc.).

Suppurative inflammation is usually preceded by catarrhal inflammation. In this condition the discharge is mucopurulent and ulcers are apt to form. A trivial loss of substance permits of regeneration, but a considerable loss is repaired by fibrous tissue which by its bulk and by contracting may interfere greatly with the functional usefulness of an organ or a canal.

A *croupous inflammation* is one in which quantities of epithelial cells are cast off the surface and there occurs upon the surface the formation of a highly fibrinous exudate (false membrane).

In *diphtheritic inflammation* the mucous membrane is destroyed and the false membrane invades the submucous tissue. Diphtheritic inflammation is due to a specific bacillus.

Classification of Inflammations.—The various forms of inflammations are—(1) *Simple* or *common*, that which is due to any ordinary traumatic, chemical, or thermal cause, and not to bacteria, such as traumatic periorbitis or sun dermatitis. It does not tend particularly to spread. As a rule, the cause of a simple inflammation is momentary in action; (2) *infective* or *specific*, that which is due to micro-organisms, as the streptococcus of erysipelas. An unsuccessful attempt has been made to charge all inflamma-

tions to bacteria. It is true that bacteria can generally be found in inflammatory areas, but that they are the only causes of inflammation is accepted by few. Infective inflammations often tend to spread widely; (3) *traumatic*, which is due to a blow or an injury; (4) *idiopathic*, which is without an ascertainable cause. There is certainly a cause, even if it cannot be pointed out, and the term "idiopathic" means that we do not know the cause; (5) *acute*, which is rapid in course and violent in action; (6) *chronic*, which follows a prolonged course; (7) *subacute*, which is intermediate in violence and duration between acute and chronic; (8) *sthenic*, characterized by high action. Occurs in strong young subjects; (9) *asthenic* or *adynamic*, occurring in the old, the debilitated, and the broken-down. In such an inflammation there is no certain limitation of the inflammation by leukocytes, and there is an indisposition on the part of the tissue-cells to form fibroblasts; (10) *parenchymatous*, affecting the "parenchyma," or active cells of an organ; (11) *interstitial*, affecting the connective-tissue stroma of an organ; (12) *serous*, characterized by profuse non-coagulating exudation (as in pleuritis) or by marked inflammatory edema; (13) *plastic, adhesive, or fibrinous*, characterized by an exudation which glues together adjacent surfaces, as in peritonitis; (14) *purulent, phlegmonous, or suppurative*, when pyogenic cocci are present and multiply; (15) *hemorrhagic*, when the exudate contains many red blood-cells, as in strangulated hernia and in the pustules of black smallpox; (16) *croupous*, when an inflammation produces upon the surface of a tissue a fibrinous exudate which cannot be organized into tissue, and which is due to the action of micro-organisms. An exudate of this character was called by the older surgeons "aplastic lymph." It occurs most usually on mucous membrane; (17) *diphtheritic*, which differs from croupous in the fact that the false membrane is in the tissue rather than upon it; (18) *gangrenous*, an inflammation resulting in death of the part, the gangrene being due to the tension of the exudate or the violence of the poison; (19) *healthy*, when the tendency is to repair; (20) *unhealthy*, when the tendency is to destruction; (21) *latent*, an inflammation which for some time does not announce itself by any obvious symptoms, as the inflammation of Peyer's patches in typhoid fever; (22) *contagious*, when its own secretions can propagate it; (23) *dry*, without exudation; (24) *hypostatic*, arising in a region of passive congestion (as a bed-sore); (25) *malignant*, due to a malignant growth; (26) *catarrhal*, affecting a mucous membrane; (27) *neuropathic*, due to impairment of the trophic functions of the nervous system, as in perforating ulcer; and (28) *sympathetic* or *reflex*, due to disease or injury of a distant part, as when orchitis follows mumps.

Extension of Inflammation.—Inflammation extends by continuity of structure, by contiguity of structure, by the blood, and by the lymphatics. Extension by continuity is seen in phlebitis. Extension by contiguity is seen when a cutaneous inflammation advances and attacks deeper structures. Extension by the blood is seen in the formation of the smallpox exanthem. Extension by the lymphatics is witnessed in a bubo following chancre.

Terminations of Inflammation.—Inflammation may be followed by a return of the tissues to health, and this return may take place by *delitescence*, by resolution, or by new growth. By *delitescence* is meant abrupt

termination at an early stage, as when a quinsy is aborted by the administration of quinin and morphin, and the production of a sweat; *resolution* means the gradual disappearance of the symptoms when inflammation has passed through its regular stages; and *new growth* means that an inflammation has, lasted a considerable time, with ample blood-supply, and without suppuration and has gone on to the formation of fibroblasts, granulation tissue, and fibrous tissue. Inflammation may be followed by death of the inflamed part, or necrosis. Death of the part may be due to suppuration, ulceration, or gangrene.

The **causes of inflammation** are—*predisposing*, or those residing in the tissues, and rendering them liable to inflame; and *exciting*, or those which directly awake the process into activity. The first may be thought of as furnishing inflammable material; the second may be regarded as sparks of fire.

Predisposing causes are those which impair the general vigor, injure the blood, weaken the tissues, or lower nutritive activities. Among these causes are shock, hemorrhage, nervous irritation, gout, rheumatism, diabetes, Bright's disease, alcoholism, and syphilis. Plethora renders a person liable to sthenic inflammations (those characterized by high action). Tissue debility renders one prone to adynamic or asthenic inflammations.

Exciting Causes.—The exciting causes of inflammation are—*traumatic*, as blows and mechanical irritation; *chemical*, as the stings of insects, ivy poison, etc.; *thermal*, heat and cold; and *specific*, the micro-organisms, causing, for instance, tuberculous peritonitis or erysipelas.

Some writers insist that every inflammation is due to the action of micro-organisms, but this statement lacks proof. They maintain that inflammation is a destructive microbic process which cannot bring about repair, and that repair only begins when inflammation ends. As Adami points out, the advocates of this view argue that swelling, pain, and discoloration point to the existence of inflammation; that repair can take place when these phenomena are absent, hence inflammation is not present when repair begins. As a matter of fact, swelling, discoloration, and pain are phenomena often but not invariably associated with inflammation; and in inflammation one or all of these phenomena may be absent. Because these signs are not discovered is no proof that inflammation does not exist. We believe that inflammation is not always due to microbes and is not always a destructive process, but may be from the start conservative and reparative. It is the reaction of the tissue to injury and is the first step on the road to repair.*

Symptoms of Acute Inflammation.—Inflammation, if at all severe, announces its presence by symptoms which are both *local* and *constitutional*. The local symptoms are heat, pain, discoloration, swelling, and disordered function; the chief constitutional symptom is fever.

Local Symptoms of Inflammation.—The most prominent local symptoms were known centuries ago to the famous Roman, Celsus, who stated them as "*rubor, calor cum tumore et dolore*"—redness and heat with swelling and pain. As set forth to-day, the local symptoms are—(1) heat; (2) pain; (3) discoloration; (4) swelling; and (5) disordered function.

Heat is due to the passage of an increased quantity of blood through the

* See Adami's masterly article in Allbutt's "System of Medicine."

damaged area and to the arrival at the surface of the body of warm blood from internal parts. Although an inflamed part may be, and usually is, warmer than the surrounding parts, its temperature is never greater than the temperature of the blood. This increase of heat is especially noticeable when we contrast the feeling of an arm affected with erysipelas with the sound arm; the diseased arm feels much warmer, but still its temperature is not above the general body-temperature. An extremity in health, as is well known, shows on the surface a temperature below that of the blood; in an inflamed state the temperature may nearly equal that of the blood. Heat is always present in inflammation of a superficial part. The surgeon examines for heat by placing his hand upon the suspected area and then placing it upon a corresponding portion of the opposite side of the patient, in order to note the contrast. If great accuracy is desired, a surface thermometer is used.

Pain is a constant and conspicuous symptom. It is due to stretching of or pressure upon nerves from exudate; to irritation of nerves; or to inflammation of the nerves themselves, producing cellular changes. Pain is associated with *tenderness* (pain on pressure), it is aggravated by motion and by a dependent position of the part, and it varies in degree and in character. In serous membranes it is acute and lancinating, like dagger-thrusts; in connective tissue it is acute and throbbing; in large organs it is dull and heavy; in the bone it is gnawing or boring; in the skin and mucous membrane it is itching, burning, smarting, or stinging; in the urethra it is scalding; in the testicle it is sickening or nauseating; in the teeth it is throbbing; and in inflammation under tense fascia it is pulsatile. Pain in inflammation after presenting itself in one form may change in character. If a pain becomes markedly throbbing, suppuration may be anticipated. Pain does not always occur at the seat of trouble, but may be felt at some distant point. This is known as a "sympathetic" pain, and means that a nervous communication exists between the inflamed part and a distant area, a nerve-trunk referring pain to its peripheral distribution. Tenderness, however, is detected at the seat of trouble.

Pain of hepatitis is often felt in the right shoulder. Pain at the point of the shoulder or in the shoulder-blade is felt also in gall-stones and in cancer of the liver. The pain arises in filaments of the pneumogastric from the hepatic plexus, which filaments reach the spinal accessory, pain being expressed in the branches of the spinal accessory which supply the trapezius and communicate with the third and fourth cervical nerves.*

Pain of coxalgia is often felt on the inside of the knee, because the obturator nerve, which sends a branch to the ligamentum teres, also sends a branch to the interior and to the inner side of the knee-joint.

Inflammation of an eye with increased tension causes brow-ache. *Inflammation of the neck of the bladder* causes pain in the head of the penis. *Inflammation of a testicle* cause pain in the groin. *Renal calculus and pyelitis* cause pain in and retraction of the testicle, and pain in the loin, groin, or thigh.

If the covering of an organ is involved, pain becomes more violent; for instance, hepatitis becomes much more painful when the perihepatic structures are attacked. Inflammation without pain is known as "latent" (as the inflammation of Peyer's patches in typhoid). The sudden disappearance of

* Embleton's view in Hilton on "Rest and Pain," a book every student should read.

inflammatory pain, when not due to the administration of opiates, suggests the possibility of gangrene, because analgesia exists in gangrene. The characteristics of inflammatory pain are that it comes on gradually, has a fixed seat, is continuous, is attended by other inflammatory symptoms, and is increased by motion, by pressure, and by a dependent position of the part. If there be no tenderness in a part, the source of the pain is not local inflammation; but tenderness may exist when there is no local inflammation, as in pain referred from a distant part. Pain of inflammation does not correspond to an exact nervous distribution. If pain corresponds exactly to the area of a nerve's distribution, the cause of it is acting on the nerve-trunk or on its roots. If the cutaneous surface is involved, the lightest touch causes pain. If touching the skin produces no pain, but deep pressure does produce it, the deeper structures are the source. Pain in muscle and ligament is developed by motion; in muscle, by contraction, but not by passive movements with the muscle relaxed; in ligament pain is developed by active or passive movements which stretch the ligament. If, for example, a man with a stiff neck has pain on the right side of the back of his neck on voluntarily turning his face toward the left shoulder, but is without pain when his face is turned by the surgeon, who, conversely, induces pain by turning the patient's face far to the right, this condition indicates the trouble to be muscular. If, however, no pain arises on turning the face to the right, but it is manifest on turning the face actively or passively to the left, the pain is in those ligaments which stretch when the face is turned to the left.* In inflammation of the synovial membrane gentle passive motion in any direction causes pain.

The pain of colic differs from that of inflammation. It is sudden in onset, intermits, recurs in paroxysms, and is relieved by pressure. The pain of inflammation is gradual in onset, is continuous, and is made worse by pressure. The pain of neuralgia is often preceded by cutaneous anesthesia of the skin of the part, is very paroxysmal, comes on suddenly, darts through recognized nerve-areas, the attack lasts some hours, and is apt to recur at a certain hour. It presents no general tenderness, as does inflammation, but we may find several points which are acutely sensitive to pressure (Valleix's *points douloureux*). The tender spots of Valleix are met with in *inveterate* neuralgia, and occur at points where nerves "pass from a deeper to a more superficial level, and particularly where they emerge from bony canals or pierce fibrous fasciæ."†

Pain is often of great value by calling attention to parts diseased; but it may be a terrible evil, racking the organism and even causing death. If pain continues long, it becomes in itself formidable: it prevents sleep, it destroys appetite, and it deteriorates the mind, and one of the surgeon's highest duties is to relieve it. The *physiognomy or expression of physical pain* presents the following characteristics: Heavy fulness about the eyes, and drooping of the angles of the mouth, added to appearances due to anemia, widespread tremor, etc. The absence of the physiognomy of pain in a person who complains of great agony is a strong indication that the patient exaggerates the gravity of his sufferings or deliberately deceives.

Discoloration arises from determination of blood to the part; hence the

* "Surgical Diagnosis," by A. Pearce Gould.

† Anstie, "Neuralgia and Diseases which Resemble It."

more vascular the tissue, the greater the discoloration. A non-vascular tissue presents no discoloration, though we usually find discoloration adjacent in the zone of blood-vessels which furnish the tissue with nutriment. Discoloration is most intense at the focus or center of inflammatory action. Discoloration varies in tint and in character according to the tissue implicated and the nature of the inflammation. It may be circumscribed or diffuse. Arborescent redness means a distribution in dendritic lines. Linear discoloration signifies redness running in straight lines, as in phlebitis. Punctiform discoloration occurs in points, and is due to vascular rupture. Maculiform redness resembles an ecchymosis or blotch. Dusky discoloration points to suppuration.

Inflammation of the throat and skin produces scarlet discoloration; inflammation of the sclerotic coat of the eye and of the fibrous coat of muscle produces lilac or bluish discoloration; inflammation of the iris produces brick-dust, grayish, or brown discoloration; erysipelas causes a yellowish-red discoloration; secondary syphilis causes a copper-hued discoloration; and tonsillitis causes a livid discoloration. A tuberculous ulcer is of a purple color on the edge. Gangrene is shown by a black discoloration. A scorbutic ulcer is surrounded by an area of violet color.

Redness as a sign of inflammation must be permanent and joined with other symptoms. Redness due to inflammation disappears on pressure, but returns as soon as the pressure is removed. If redness is due to staining of the surface by dye, pigmentation, or extravasation of blood, pressure will not blanch the spot. If on taking off pressure the redness of inflammation rapidly returns, the circulation is active; if, on the contrary, it very slowly reappears, the circulation is very sluggish and gangrene is threatened. Subcutaneous hemorrhage gives rise to a purple-red color which does not fade when subjected to pressure. Stains of the surface by dyes fail to disappear on pressure, are distributed over a considerable surface, show a hue which is uniform throughout, are obviously superficial, are not associated with other signs of inflammation, and can be washed away.

A. Pearce Gould, in his excellent little work upon "Surgical Diagnosis," tells us that the color of a hyperemic surface may furnish important information. Lividity may mean failure of the heart and lungs, or simply venous congestion in the part. In lividity from obstruction of the lungs or heart the color slowly returns after pressure has driven it out. In lividity due to local congestion the color quickly returns when pressure is released and the dilated veins are often distinctly visible. Of course, in a local trouble, when the circulation becomes impaired to such a degree that gangrene is threatened, the lividity fades very slowly on pressure and reappears very slowly on the release of pressure.

Swelling or tumefaction arises in small part from vascular distention, but chiefly from effusion and cell-multiplication. The more loose cellular material a part contains, the more it swells; hence the eyelids, scrotum, vulva, tonsils, glottis, and conjunctivæ swell very largely when inflamed. A swelling is soft or edematous when due to uncoagulable effusion; is brawny and doughy when due to coagulated effusion; is hard and elastic when produced by proliferating cells. Swelling may do good by unloading the vessels and acting like a blister or local bleeding, or it may do great harm by pressing upon the vessels and cutting off the blood-supply. Swelling of the conjunctiva, or

chemosis, may cause sloughing of the cornea, and swelling of the prepuce may cause gangrene. A swelling may do harm by obstructing a natural passage, as in edema of the glottis, when the larynx becomes blocked; or by compression of a normal channel, as in the swelling of the perineum, when the urethra is compressed. A swollen area may be covered with blisters or blebs. This condition is noted particularly in burns and fractures.

Disordered function is always present in inflammation. It may be manifested by *increased tenderness* or sensibility, a slight touch, it may be, producing torturing pain. Parts almost or entirely destitute of feeling when healthy (as tendons, ligaments, and bones) become highly sensitive when inflamed. It may be manifested by *increased irritability*. In dysentery the colon constantly contracts and expels its contents; the stomach does likewise in gastritis; and the bladder acts similarly in cystitis. Spasmodic twitching of the eyelids occurs in conjunctivitis, and twitching of the muscles in fracture and after amputation.

Impairment of Special Function.—In inflammation of the eye, when an attempt is made to look at objects, the lids close spasmodically, and even a little light causes great pain and lachrymation (photophobia). In inflammation of the ear noises cause great suffering, and even when in a quiet room the patient has subjective buzzing and roaring sounds in his ears (tinnitus aurium). In coryza the sense of smell, in glossitis the sense of taste, in dermatitis the sense of touch, and in laryngitis the voice may be lost. In inflammation of the brain the mind is affected; in arthritis the joints can scarcely be moved; and in myositis it is difficult and painful to employ the muscles.

Derangement of Secretions.—In dermatitis the sweat is not thrown off; in hepatitis bile is not properly secreted; and in nephritis urea is not satisfactorily removed. The secretions may undergo important changes of composition. The sputum in pneumonia is rusty, and dysentery causes a discharge of bloody mucus (Gross).

Derangement of Absorbents.—In the height of an inflammation the absorbents are blocked and clogged by coagulated fibrin, and they cannot perform their offices.

Constitutional symptoms of acute inflammation may be absent, and often are in moderate or limited inflammations; but in severe, extensive, or infective inflammations the symptom group known as *fever* is certain to exist. This is known as symptomatic, sympathetic, or inflammatory fever, and it arises in non-septic cases from the absorption of aseptic pyrogenous exudate and in microbic inflammations from absorption of pyrogenous toxic products of bacterial action. In young and robust individuals an acute non-microbic inflammation causes a fever characterized by full, strong pulse, flushed face, coated tongue, dry skin, nausea, constipation, and possibly acute delirium (the sthenic type of the older authors). In broken-down and exhausted individuals an ordinary inflammation, and in any individuals a bacterial inflammation, may cause a fever with typhoid symptoms (the typhoid, asthenic, or adynamic type). Fibrin ferment is obtained from the white corpuscles; it is liberated as the corpuscles break up in the exudate, and acting on the liquor sanguinis cause the union of calcium and fibrinogen and the formation of fibrin. The absorption of fibrin ferment many believe causes aseptic fever (page 105). Inflammatory blood contains an increased amount of albumin

and salts. If a person with inflammatory fever is bled, the blood coagulates rapidly, the clot sinks, and there is found on the surface a cup-shaped coat, made up of liquor sanguinis and white cells, known as the "buffy coat"; but this is not a sign of inflammation, and occurs normally in the blood of the horse. The buffy coat forms when blood contains a great number of leukocytes, because these leukocytes sink more slowly than do the red corpuscles. Cupping occurs because the white corpuscles sink more slowly by the side of the tube than far from the sides.

Leukocytosis.—In many inflammatory and infectious diseases leukocytosis is noted. It probably measures an attempt on the part of the organism to protect itself from noxious materials. Leukocytosis is usually much more marked if pus exists than if the exudation is serous or fibrinous.

"The degree of leukocytosis may be considered a general index to the intensity of the infection and to the strength of the individual's resisting powers in reacting against it. It follows, therefore, that intense infections occurring in individuals whose resisting powers are strong, produce a decided increase; but the presence of an infection of like intensity in one whose resisting powers are greatly crippled fails to cause leukocytosis, for in such an instance the organism is so overpowered by the effects of the morbid process that it is incapable of reacting." ("Clinical Hematology," by J. C. DaCosta, Jr.).

Chronic Inflammation.—This condition progresses slowly and does not produce symptoms of severity either in the part or the body at large.

Causes.—Blood diseases, as rheumatism and gout; infective diseases, as tuberculosis and syphilis; retained pus in an ill-drained abscess; blockage of the duct of a gland; the retention of a foreign body in a part; the flow of an irritant secretion (as saliva from a fistula); repeated identical traumatisms of an occupation, etc. W. Watson Cheyne tells us chronic inflammation is not due to the ordinary pyogenic organisms (see Cheyne's article in Treves's "System of Surgery").

Tissue-changes.—These changes are practically the same as in acute inflammation, but take place far less rapidly. It is maintained by Cheyne and others that typical granulation tissue does not form, the tissues of the part being replaced by fibrous tissue. The amount of fibrous tissue produced is relatively very great. This tissue may cause permanent thickening, or may contract and thus diminish the size of a part. Contraction is very considerable in cirrhosis of the liver and in interstitial nephritis.

Symptoms.—Pain varying in intensity and character; tenderness; great swelling, which in some cases is followed by shrinking, and is usually indurated or brawny. As a matter of fact, great swelling is the most usual symptom. Sometimes there is a trivial amount of heat. There is rarely discoloration unless the skin is itself inflamed, but usually the surface veins are distinctly and sometimes they are greatly distended. There are no constitutional symptoms attributable purely to the inflammation. If there are such symptoms, they are due to the disease which induced the inflammation or to interference with the function of an organ because of the fibrous mass. (For treatment of chronic inflammation see articles upon special regions and particular structures.)

Treatment of Acute Inflammation.—The first rule in treating an inflammation must be to remove the exciting cause. If this cause is a splinter

in the part, take out the splinter; if it is a foreign body in the eye, remove the foreign body; if urine is extravasated, open and drain; take off pressure from a corn; pull out an ingrown nail; and remove microbes from an infected area by exposing, irrigating, and applying antiseptics. The rule, remove the cause, applies to a chronic as well as to an acute inflammation. If the cause of an inflammation was momentary in action (as a blow), we cannot remove it, for it has already ceased to exist. After removing the cause, endeavor to bring about a cure by local and constitutional treatment.

Local Treatment of Inflammation.—It must be remembered that the division of inflammation into stages is natural, and not artificial, and that a remedy which does good in one stage may do harm in another. Certain agents are suited to all stages of an inflammation, namely, *rest* and *elevation*.

Rest.—Physiological rest is of infinite importance, and is always indicated in acute inflammation. In the exercise of function blood is taken to a part and an existing inflammation is aggravated. Further, as Billroth has pointed out, rest prevents the dissemination of infection, because motion exposes fresh surfaces to inoculation and breaks down protective barriers of leukocytes. Its principles were first thoroughly studied by Hilton.* The means of securing rest differ with the structure or the part diseased. When rest is used, do not employ it too long. *Rest in bed* diminishes the amount of blood sent to an inflamed part and lessens the force of the circulation; hence it antagonizes stasis. It has been shown that the heart beats at least fifteen times per minute less when the patient is recumbent than when he is erect. The saving of strength and the benefit to the local condition are thus seen to be enormous. In fact, the heart saves at least twenty-one thousand beats a day. In every severe inflammation insist on the patient going to bed.

In *cerebral concussion* rest must be secured by quiet, by darkness, by the avoidance of stimulants and meat, by the application of ice to the head, and by the use of purgatives to prevent reflex disturbance and the circulation of poisons in the blood. In *inflamed joints* rest must be obtained by proper position, associated in many cases with the adjustment of splints or plaster of Paris, or the employment of extension.

In *pleuritis* partial rest can be secured by strapping the affected side with adhesive plaster or by using a bandage or a binder to limit respiratory movements. In *fractures* Nature procures rest by her splints—the *callus*—and the surgeon procures rest by his splints—firm dressings, or extension. In *cancer of the rectum* and intractable rectitis, a colostomy secures rest for the inflamed and damaged bowel. In *enteritis* opium gives rest to the bowel by stopping peristalsis. In *cystitis* rest is obtained by the administration of opium and belladonna, which paralyze the muscular fibers of the bladder. The use of the catheter gives rest to the bladder by removing urine. A cystotomy allows complete rest by permitting the bladder to suspend its function as a reservoir of urine. In cystitis from *vesical calculus* rest is obtained by cutting or crushing the stone. In *inflamed mucous membrane* rest from the contact of irritants is secured by touching the membrane with silver nitrate, which forms a protective coat of coagulated albumin. Opening an *abscess* gives its walls rest from tension. In *inflammations of the eye* light must be excluded to obtain complete rest, but tolerably satisfactory rest is given in some cases

* "Lectures upon Rest and Pain."

by the use of glasses of a peacock-blue tint. In *aneurysm* the operation of ligation cuts off the blood-current and gives rest to the sac. In *hernia* the operation gives rest from pressure. Instances of the value of rest could indefinitely be multiplied.

Relaxation is in reality a form of rest, and consists in placing the part in an easy position. In *synovitis* of the knee semiflexion of the knee-joint lessens the pain. In *muscular inflammations* relaxation relieves the pain.

Elevation.—Elevation partly restores circulatory equilibrium. A *jelon* is less painful when the hand is held up in a sling than when it is dependent. A *congestive headache* is worse during recumbency. A *gouty inflammation* in the great toe is more painful with the foot lowered than when it is raised. A *toothache* becomes worse on lying down.

Certain agents are suited to the stage of vascular engorgement, increased arterial tension, and beginning effusion. These agents are—(1) local bleeding or depletion; (2) cutting off the blood-supply; and (3) cold.

Local Bleeding.—Local bleeding, or *depletion*, is the abstraction of blood from the inflamed area. This abstraction relieves circulatory retardation and causes the blood to move rapidly onward; the corpuscles clinging to the vessel-walls are washed away, the capillaries shrink to their natural size, and the exudate is absorbed. In other words, local blood-letting increases the rate of the circulation, though not its force.

The methods of bleeding locally are—(a) puncture; (b) scarification; (c) leeching; and (d) cupping.

Puncture is recommended in inflammation, not only because it abstracts blood locally, but also because it gives an exit to effusion under fibrous membranes. It is very useful in relieving tension—for instance, in epididymitis. It is performed with a tenotome and with aseptic precautions. If numerous punctures are made, the procedure is termed “multiple puncture.” This is very useful when applied to the inflamed area around a leg-ulcer. The late Prof. Joseph Pancoast was very fond of employing multiple punctures, designating the operation “the antiphlogistic touch of the therapeutic knife.”

Scarification or Incision.—By means of scarification we bleed locally, evacuate exudate, and relieve tension. One cut or many cuts may be made, and these cuts may be deep or may not go entirely through the skin, according to circumstances. Multiple incisions are useful when applied to inflamed ulcers, ulcers in danger of gangrene, and to almost any condition of great tension. Scarification is of notable value when edema of the glottis exists. Free incision is of great benefit in periostitis and in threatened gangrene. In osteomyelitis the medullary canal must be promptly opened.

Leeching.—Leeches must not be applied to a region plentifully endowed with loose cellular tissue, as great swelling and discoloration are sure to ensue. These regions are the prepuce, labia majora, scrotum, and eyelids. Leeches should never be applied to the face (because of the scar), near specific sores or inflammations, nor over a superficial artery, vein, or nerve. A leech is best applied at the periphery of an inflammation and between an inflammation and the heart. To leech at the inflammatory focus only aggravates the trouble. Before applying leeches, wash the part and shave it if hairy. Place the leech in a test-tube or an inverted wine glass, inserting the tail or thick end first, and invert the tube so that the leech's head will come in contact with the pre-

pared skin. The leech is restrained in the tube until it "takes hold" and begins to feed, when the tube is removed. If the leeches will not bite, smear the part with milk or a little blood. Never pull off a leech; let it drop off. It will usually drop off when full, but if it refuses to do so, sprinkle it with salt. After removing a leech, employ warm fomentations if continued bleeding is desired. Sometimes the bleeding persists, but this may be arrested by styptic cotton and pressure. In some rare cases the bleeding continues in spite of pressure. This is due to the fact that the tissue contains a considerable quantity of a material secreted from the throat of the leech, which material prevents coagulation of blood. In such a case excise the bite and the area of tissue adjacent to it, and suture the wound. Leeching leaves permanent triangular scars. The Swedish leech, which is preferred to the American, draws from two to four drams of blood. After a leech has been removed, if we desire to use it again, place it in salt water. This causes it to vomit the blood which it has taken up. Leeching has both a constitutional and a local effect. It is at the present time used comparatively rarely, but it is employed by some practitioners over the spermatic cord in epididymitis, on the temple in ocular inflammation, and over the right iliac region to relieve the pain in mild cases of appendicitis.



Fig. 29.—Scarificator.

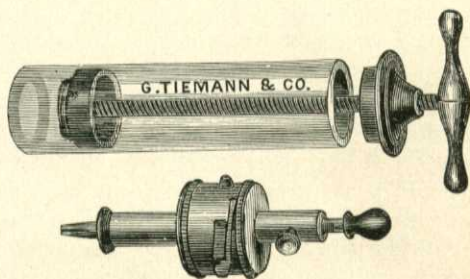


Fig. 30.—Heurteloup's artificial leech.

Cupping.—Dry cups deviate blood from a deeply placed inflamed area to the surface. Wet cups actually remove blood.

Dry Cups.—Dry cups are applied without first incising the skin. One or more may be applied. A special instrument is sold in the shops for the performance of dry cupping. It consists of a glass bell, with a globular and hollow top of rubber. The rubber bulb is emptied of air by squeezing, the glass bulb, the edges of which have been greased, is pushed upon the skin, and the compression is relaxed upon the rubber bulb. A partial vacuum is created, and an area of skin and subcutaneous tissue full of blood rises into the glass bell.

Cupping can be easily performed by means of a tumbler. The edge of the glass is greased; a bit of blotting-paper wet with alcohol is placed in the bottom of the tumbler and lighted. After a brief period the glass is inverted and placed upon the skin, which has been dampened with warm water. As the air in the glass cools, the tissues rise into the partial vacuum.

Wet Cups.—Wet cups draw blood, and the skin should be cleansed before they are applied. In wet cupping apply a cup for a moment, remove it, incise

or puncture the skin, and replace the cup to draw the requisite amount of blood. Incisions may be made by an ordinary scalpel, a lancet, or a scarificator, a cup being then applied. An excellent scarificator is shown in Fig. 29. In this instrument concealed blades are thrown out by touching a spring. Baron Heurteloup devised an instrument (Fig. 30) in which the incision is made by a scarificator. The blood is drawn out by a pump, the tube being placed upon the cut area and the withdrawal of the piston creating a vacuum. This instrument is known as the "artificial leech." After scarification and the application of the cup, the partial vacuum draws blood into the cup; when the surface ceases to bleed, the cup is removed, and if further bleeding is thought desirable, the clots are wiped away and the cup is again applied, and after its removal warm fomentations are used (Cheyne and Burghard). Wet cupping is of value in pleuritis, pericarditis, and nephritis.

Cutting off the Blood-supply.—Onderdonk, of New York, in 1813 recommended ligation of the main artery of a limb for the cure of inflammation in important structures supplied by the vessel. The procedure was warmly advocated by Campbell, of Georgia, for the treatment of gunshot wounds of joints. This plan of treatment is now not to be considered for a moment; antiseptics furnish us with a safer and more certain plan. Van-zetti, of Padua, advocates digital pressure to cut off the blood-supply to an inflamed part.

Cold.—Cold is a very powerful and useful agent if used judiciously and applied at the proper time. It is valuable because of its reflex effect upon the vessels of the inflamed area rather than because of direct action upon the cells of a part. It should be used early in the case, before stasis occurs. It is not to be used in the later stages of inflammation, for it will then only aggravate the existing state; in fact, when there is considerable exudation cold does no good.

Cold acts by constricting the vessels of a hyperemic area, thus lessening the amount of blood sent to the part, and preventing the evolution of the process into the stage of stasis and exudation. Further, it prevents the migration of leukocytes, retards cell-proliferation, relieves pain and tension, and lowers temperature. If cold is too intense, if it is kept too long applied, if it is used late in an inflammation, if it is used upon an old or feeble patient, or if it is employed when there is much exudation or a condition of tissue strangulation, it does actual harm. It lessens the nutritive activity of cells, constricts the lymph-spaces and channels, increases existing stasis, and hence lowers the vitality of the tissues. If the parts are constricted, as in strangulated hernia, or if they are compressed by a large exudate, or fed by diseased blood-vessels, cold may cause gangrene. Nancrede, in his "Principles of Surgery," points out that in an inflammation stasis soon arises at the focus of the inflammation, and there is an area of stasis surrounded by a zone of hyperemia. Cold benefits the hyperemic zone but aggravates the stasis. Nancrede cautions us as follows: "Judgment is therefore requisite to decide whether the evil at the focus will not outweigh the good exerted at the periphery." * Nancrede further points out that cold must not be used intermittently; but if employed at all, must be continuously applied. If cold is applied intermittently, there will be a reaction whenever it is removed, and this reaction causes increased

* "Principles of Surgery."

hyperemia. Hence, cold must be "continued in action to prevent reaction." If during the employment of cold the skin becomes purple and congested and the circulation feeble, at once discontinue the use of it, as its continuance will be dangerous.

Cold may be used as wet cold or as dry cold.

Wet Cold.—Wet cold is easily applied, but it is much more depressing than dry cold, is likely to produce discomfort, macerates the skin, and may lead to the formation of excoriations, etc. A part can be subjected to wet cold by the application of evaporating fluids or the use of a siphon. When wet cold is used inspect the part at frequent intervals, and discontinue the treatment if evidences of stasis become positive. Evaporating fluids are extensively employed. If such a fluid is used, never cover the part with a thick dressing. If this should be done, the fluid will not evaporate with sufficient rapidity to produce cold. A piece of thin muslin or flannel should be moistened with the fluid and laid upon the part, and be kept constantly moist by the application from time to time of small quantities of the liquid. Lead-water and laudanum is used extensively, and probably owes its chief value to the fact that it produces cold on evaporation. Lead-water and laudanum is composed of \mathfrak{z} j of laudanum, \mathfrak{z} j of liquor plumbi subacetatis, and 1 pint of water. Liquor plumbi subacetatis dilutus may be used without laudanum. It is thought that the addition of laudanum tends to allay pain. A solution of ammonium chlorid may be used in the strength of \mathfrak{z} j of the drug to 2 quarts of water. If ammonium chlorid is used for more than a short period of time, it is prone to cause the formation of blisters which are irritable and painful. Cheyne and Burghard use the following formula: $\frac{1}{2}$ ounce of ammonium chlorid, 1 ounce of alcohol, and 7 ounces of water. Plain spring-water, iced water, or a mixture of alcohol and water may be used. The *siphon* is occasionally used. If there is a wound, the fluid must be aseptic or antiseptic. In conjunctivitis, cold is applied to the eye by means of linen or muslin soaked in iced water laid upon the closed lids, and frequently changed.

To apply wet cold by means of a siphon, the part is covered with one layer of wet linen or muslin and is laid upon a rubber sheet folded like a trough and emptying into a bucket. A vessel filled with cold water is placed upon a higher level than the bed. A wet lamp-wick is now taken, one end is inserted into the water of the vessel, and the other end is laid upon the part. Capillary action and gravity combine to keep the part moist. A rubber tube may be used instead of a wick. If a tube is employed, tie it in a knot or clamp it so that the fluid is delivered drop by drop (Fig. 31). Ordinary water or iced water can be used. If the water be too warm, it can be reduced to about 45° F. by adding 1 part of alcohol to every 4 parts of water. A mixture of 5 parts of nitrate of potassium, 5 parts of chlorid of ammonium, and 16 parts of water produces great cold.

Dry cold is more manageable and more generally useful than wet cold. It is applied by means of a rubber bag or a bladder filled with ground or finely cracked ice, several folds of flannel being first laid over the part. The flannel collects the moisture from the "sweating" bag and thus prevents maceration of the skin. Further, it saves the tissue from being subjected to too much direct cold and enables us to obtain the beneficial reflex effect. The ice-bag of India-rubber is widely used. We can venture to apply by means of the

ice-bag a greater degree of cold than it is proper to apply by the use of fluids, as dry cold is not so likely to induce gangrene as is moist cold. If there is much tenderness, the weight of an ice-bag causes pain, and it is best to suspend it from a frame, so that it lightly touches the part. The frame is the same as is used to keep the bedclothes from a fractured leg, and is made from barrel hoops. During the time an ice-bag is being used the part must be inspected at brief intervals to see that the circulation is not unduly depressed. The ice-bag is frequently used in joint-inflammation, in intracerebral inflammation, in the early stage of appendicitis, in epididymitis, and in acute myelitis. If a joint is sprained, the immediate application of an ice-bag is of great service. A part can be encircled with a rubber tube through which iced water is made to flow (Fig. 32). Even when this apparatus is used the part should

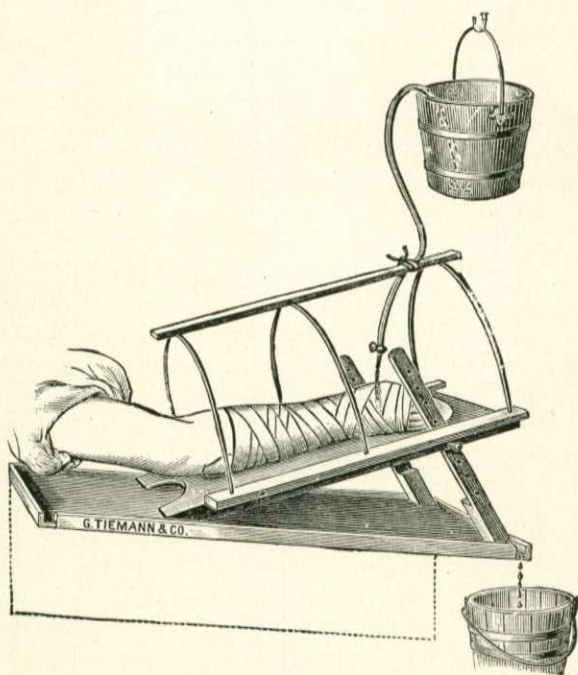


Fig. 31.—Siphon (Esmarch).

first be wrapped in flannel. Leiter's tubes, which are tubes of lead made to fit various regions and which carry a stream of cold water, can also be used. A piece of flannel must be placed between the tube and the skin. The temperature of these tubes can be lowered to any desired degree by lowering the temperature of the circulating fluid. Cheyne and Burghard caution us to use a fluid at a temperature not under 50° or 60° F., to inspect the part every three or four hours, and not to employ the tubes longer than twenty-four hours.*

Heat is employed by some early in an inflammation. It is rarely beneficial at this stage, except when applied by a hot-air apparatus for the treat-

* "Manual of Surgical Treatment," by W. Watson Cheyne and F. F. Burghard.

ment of an injured joint. It is true that a degree of heat which does not actually destroy the tissues will contract the vessels as does cold; but this

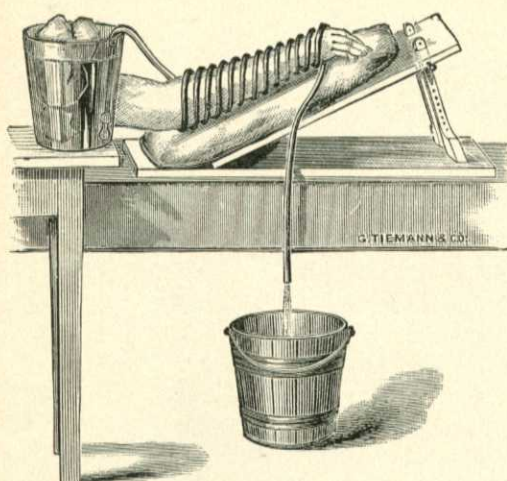


Fig. 32.—The Esmarch cooling coil.

degree of heat will not be borne by the patient, and will not be tolerated unless but a limited portion of a superficial part is involved.

Certain agents are suited to the stage of fully developed inflammation, when there is a great deal of swelling due to effusion and cell-proliferation. The indication in this stage is to abate swelling by promoting absorption. This is accomplished by (1) compression; (2) the local use of astringents and sorbefacients; (3) the douche; (4) massage; and (5) heat.

Compression.—Compression is especially useful in fully developed or in chronic inflammation, but it will do good also in the first stage. Compression is of great usefulness; it supports the vessels and causes them to drink up effusion, and it strongly rouses the absorbents. This agent is valuable in most external inflammations with marked swelling and is particularly beneficial in chronic inflammation. In erysipelas of an extremity the part should be elevated and the extremity bandaged from the periphery to the body. In ulcers, especially those with hard and blue edges, the use of Martin's elastic bandage or of straps of adhesive plaster gives decided relief. In chronic inflammation of a joint elastic compression is of great value. In epididymitis, after the acute stage, the testicle may be strapped with adhesive plaster. In lymphadenitis compression by a weight or by a bandage is very generally employed. In fractures compression not only antagonizes spasm, but often combats the swelling and pain of inflammation. Compression must be judicious: it must never be forcible, and it must not be applied to a limb without including the distal portion of the extremity (never, for instance, strongly compress the elbow without including the hand, nor the palm without bandaging the fingers). Injudicious compression causes severe pain and great edema, and may produce gangrene.

Astringents and Sorbefacients.—Astringents may have direct value in inflammation of the skin, but it is not likely that they have any effect on deep-seated inflammation. When used in evaporating lotions in an earlier stage of inflammation the cold does good rather than the drug. Lead-water and laudanum is extensively employed and it is thought to somewhat allay inflammatory pain. The mixture certainly gives comfort in cutaneous erysipelas. It is very doubtful if lead-water is of any service at any stage of a deep-seated inflammation or in any fully developed inflammation. If used after the first stage it must not be applied as an evaporating lotion, because

cold will do harm. Pieces of lint are soaked in the fluid and placed upon the part, and a bandage is applied. The wet lint which has been placed upon the part is covered with oiled silk or a rubber dam before the bandage is applied. If used in the latter manner, the body-heat is retained in the part. If greater heat is required, a hot-water bag can be placed outside of the bandage. Lead-water is not used in treating wounds and hot lead-water should not be applied to a cutaneous inflammation.

Tincture of iodine is astringent, sorbefacient, counterirritant, and antiseptic. It must not be used pure. For application to adults it should be diluted with an equal amount of alcohol, and for children with 3 parts of alcohol. In using iodine, paint it upon the part with a camel's-hair brush and fan it dry, applying one or more coats. The repeated application of iodine to the skin is of great benefit in inflammation of the glands, muscles, tendons, joints, and periosteum. Iodine is apt, after a time, to vesicate, and must not be used in full strength, because it is irritant. It is of special value in chronic inflammation. In deep-seated inflammation it acts as a counterirritant.

Nitrate of silver is a non-irritating astringent of considerable value in inflammation of mucous membranes. It forms a protective coat of coagulated albumin, and is much used in treating the throat, mouth, and genital organs. In urethral inflammation a proteid compound of silver known as protargol may be used.

Ichthyol is a drug of decided efficiency in reducing inflammatory swelling. It is usually employed in ointments, the strength being from 25 to 50 per cent. It is best exhibited with lanolin. When rubbed in over inflamed glands, joints, and lymphatic enlargements, it is of great value. In children a 25 per cent., and in adults a 50 per cent., ointment should be rubbed in thoroughly twice a day. In inflammatory skin-disease, synovitis, thecitis, frost-bite, bubo, chilblain, and in many other conditions, acute or chronic, the use of ichthyol is indicated. The odor of ichthyol is highly disagreeable, and when ordered for a refined person it had better be deodorized. For this purpose Hare uses oil of citronella, ℥xx to ʒj of ointment.

Mercurials.—Blue ointment, pure or diluted to various strengths, is extremely valuable. It is spread upon lint and kept applied over areas of fully developed inflammation. It is especially useful in acutely or chronically inflamed joints, glands, tendons, etc. Blue ointment is strongly irritant, and will soon blister or excoriate a tender skin. It is very beneficial in periostitis, and is employed largely in chronic inflammations.

The Douche.—The douche consists of a stream of water falling upon a part from a height. The water may be poured from a receptacle or may run through a tube, and may be either hot or cold. Alternating hot and cold streams are very popular in inflammations of joints and tendons, especially in chronic inflammation. This mode of application is known as the "Scotch douche." It restores the tone of the blood-vessels and plasma-channels and promotes the absorption of inflammatory exudate. If the part is very tender, the water should be squeezed upon it from sponges. In a sprain of the knee-joint, after a time, when thickening has occurred, pour upon the part daily, from a height, first a pitcherful of very hot water, then a pitcherful of very cold water; then use friction with a hand greased with cosmolin. Hot vaginal douches are generally employed in pelvic inflammations.

Massage.—Massage is a procedure not frequently enough employed. It is very useful in some acute inflammations, though in these it must be gentle. It is of great service in the treatment of sprains of joints and fractures. It is influential for good in chronic inflammations at the period when rest is abandoned. It acts by promoting the movements of tissue-fluids (blood, lymph, and areolar fluid), stimulating the absorbents, strengthening local nervous control, and thus improving nutrition. Passive motion in joints acts as massage.

Heat.—Heat may be used continuously or intermittently, and may be either moist or dry. A considerable degree of heat will act like cold and contract the vessels. The degree necessary to cause vascular contraction would not destroy the tissue, but would produce discomfort, which discomfort would become unbearable during the continuance of the application. Therefore, heat is rarely used in the earliest stage of an acute inflammation. It is hard to state exactly when heat should be substituted for cold. Certainly after a day or two it is preferable. The sensations of the patient may be of use in determining this point, and if heat gives comfort it may be used. Moderate heat should be used when inflammation is not very superficial. In a cutaneous inflammation heat usually does harm, because it increases the congestion of an inflamed superficial part. In deep-seated inflammations heat to the surface acts as a revulsive or counterirritant. Thus a poultice to the chest may do good in the first stage of pneumonia, and cauterization of the skin near a joint may benefit an acute synovitis. The use of heat for purposes of counterirritation will be discussed under the head of Counterirritants. A moderate degree of heat applied over a fully developed and not too superficial inflamed area dilates the vessels, especially the veins. Thus circulation is re-established in an area filled with stagnant blood or blood which is scarcely moving, fluid exudate is absorbed, tension is lessened, the lymph-spaces and vessels distend, and lymphatic absorption becomes active. The application of heat increases the ameboid activity of the leukocytes, phagocytes gather in great numbers and surround an area of infection, and those which have taken up bacteria or tissue debris hurry away.* Heat notably lessens the pain of inflammation. It is often used purely to relieve pain.

The *forms of heat* are—(1) fomentations; (2) poultices; (3) water-bath; and (4) dry heat.

Fomentation is the application to the skin of a piece of flannel containing a hot liquid. A basin is warmed and over the top of the basin a towel is placed. A piece of flannel folded in two or three thicknesses is laid upon the towel and boiling water is poured upon it. By twisting the towel the water is squeezed out. Great care must be taken to squeeze the water out of the flannel, otherwise the skin may be scalded. The hot flannel is laid upon the skin over the disordered part. A rubber dam larger than the flannel is placed over it, a mass of cotton is laid upon the rubber dam, and a bandage is applied. The fomentation must be changed within an hour unless a hot-water bag has been placed outside the bandage, in which case it need not be changed for two hours or more. The flannel which is dipped into the hot liquid is known as a "stupe." The turpentine stupe is made by wringing out the flannel as above

* Nancrede, in "Principles of Surgery."

and then putting upon it from 10 to 20 drops of turpentine. Instead of fomenting the part, steam may be thrown upon it. Fomentations are used chiefly for their reflex influence over deep congestions or inflammations. The liquid of a fomentation may, if desired, contain corrosive sublimate, carbolic acid, or other agents. A fomentation containing an antiseptic is known as an antiseptic fomentation. An *antiseptic fomentation*, or, as it is often called, an *antiseptic poultice*, is made and applied as follows: Gauze is used instead of flannel, and is laid upon the towel over the basin as previously described. A very warm solution of corrosive sublimate (1 : 1000) is poured upon the gauze, the material is partly wrung out, placed upon the part, covered with a rubber dam, and upon it a hot-water bag is placed. Fomentations are very useful in relieving pain in any stage of an inflammation and act also as counter-irritants. Fomentations are used in preference to ordinary poultices if there is any probability of a surgical operation becoming necessary, because skin to which a poultice has been applied cannot be satisfactorily sterilized. The antiseptic fomentation is of great service in removing sloughs from foul wounds and ulcers. It is the only form of poultice which is admissible when the skin is broken.

Poultice or Cataplasm.—A poultice is a soft mass applied to a part to bring heat and moisture to bear upon it. Poultices can be made of ground flaxseed, of slippery-elm bark, of arrowroot, starch, bread and milk, potatoes, turnips, etc. To make a flaxseed poultice, scald a spoon and a tin basin, put the flaxseed into the dry hot basin, and pour upon it boiling water in sufficient quantity to form a thick paste. The proper consistence is found when the mass would stick if it were thrown against a wall. It is now spread to the thickness of a quarter of an inch upon a piece of warm muslin, a free edge being left all around, the edges of the muslin are turned in, and the flaxseed is covered with a bit of gauze to prevent adhesion to the skin. The poultice should be placed upon the part and be covered outside with oiled silk, a rubber dam, or waxed paper. A mass of cotton is applied outside of the rubber and the poultice is held in place by a bandage or binder. It can be kept very warm for a considerable period by placing upon it a bag filled with hot water. If a hot-water bag is not employed, a poultice should be changed every two hours. Spongiopilin, when moistened with hot water, is a good substitute poultice. Lint soaked with hot water and covered with some impermeable material does very well. The fermented poultice, which was once popular for gangrenous ulcers, was made by sprinkling yeast upon an ordinary cataplasm. The charcoal poultice is made by stirring charcoal into the usual poultice-mass. A poultice containing opium is known as a "sedative" poultice. About gr. ij of opium to the ounce of poultice-mass may relieve pain. Flaxseed is a vegetable material, adheres to the skin, enters the mouths of glands and follicles, undergoes decay, and can be removed only with great difficulty. The preparation of an antiseptic *poultice* or fomentation is described above. Poultices must not be kept on the part too long, as they will cause vesication, especially in adynamic conditions. If a poultice is causing vesication, remove it and do not replace it, or replace it after sprinkling the part and the poultice with powdered oxid of zinc. If suppuration exists or is seriously threatened, do not waste time by using poultices, but incise at once. Incision may prevent suppuration by relieving tension, affording drainage, and permitting the

local use of antiseptics. If pus exists, it cannot be evacuated too soon. To use poultices and delay incision is often productive of irreparable harm. After incision of a purulent focus it is common practice to apply an antiseptic fomentation in order to draw quantities of leukocytes to the part and thus limit the spread of infection and stimulate granulation.

Hot-water Bath.—The continuous hot bath is now rarely employed except in burns and cases of phagedena, when it often proves curative. In these cases an antiseptic agent may be dissolved in the water. Continuous immersion in a warm bath is regarded favorably by some surgeons for the treatment of sloughing wounds and large purulent areas. The immersion of a part from time to time in water as hot as can be tolerated is useful in fully developed and in chronic inflammation. Such immersion benefits an inflamed joint, lessening the pain, swelling, and stiffness.

Dry heat is applied by a metallic object dipped in hot water and laid upon the part; by Leiter's tubes, through which hot water flows; by the hot-water bag or by the hot-air apparatus. Some surgeons use the hot-water bag in cases of mild appendicitis, in order to favor the formation of adhesions. The hot-water bag is often soothing and beneficial when laid upon an inflamed joint, or on the perineum or the hypogastric region in cystitis. A bag of hot sand, a hot brick, or a bottle or can of hot water may be used instead of the bag. The hot-air apparatus is of very great service in the treatment of inflamed joints (*vide* dry hot-air apparatus).

Treatment when Suppuration is Threatened.—When suppuration is threatened, ordinary hot fomentations or antiseptic fomentations must be used, and the part must be kept at rest. As previously explained, the flaxseed poultice is inadmissible. When suppuration is threatened, the use of heat causes the collection of multitudes of leukocytes, which tend to limit the area of infection and destroy bacteria. Even when suppuration is not prevented, heat aids in the rapid breaking down of the diseased tissue at the focus of the inflammation and causes hordes of leukocytes to gather and encompass the suppurating tissue, and these leukocytes prevent the spread of the infection.

In most cases, when suppuration is obviously inevitable or seriously threatened, a *free incision* will be of greatest benefit.

Irritants and Counterirritants in Inflammation.—*Irritants* attract an increased supply of blood to the part whereon they are applied, and are used for their local effects. *Counterirritants* are used to affect by reflex influence some distant part. In chronic inflammation irritants may do good by promoting the blood-supply, thus favoring the removal of exudates (liniment for rheumatism and synovitis, and nitrate of silver for ulcers). Counterirritants are powerful pain-relievers when used over an inflamed structure; they bring blood to the surface and are thought by many writers to cause anemia of internal parts, the site and area of anemia depending on the site, the area, and the duration of the surface irritation. Some recent studies seem to indicate that counterirritation produces hyperemia of the superficial part, compensatory anemia of surrounding regions, and anemic edema of the subcutaneous tissue and muscles (W. Weeksberg, "Zeit. f. klin. Med.," Bd. xxxvii, H. 3 u. 4). Nancrede dissents from the statement that counterirritants cause anemia of internal parts; and he maintains that they irritate deeper parts

and cause more external blood to be taken to them. He claims that a blister applied to the chest produces a hyperemic area in the pleura, and refers to Furneaux Jordan's opinion that direct irritation to the surface over a joint adds to synovial hyperemia, and that consequently in joint-inflammation counterirritants should be applied above and below a joint, but not directly over it. As a matter of fact, we know clinically that powerful counterirritation directly over an inflamed superficial joint is occasionally followed by an aggravation of the trouble, and that in pericarditis blistering directly over the pericardium may, as pointed out by Brunton, make the condition worse. Counterirritants not only relieve pain in the earlier stages of inflammation, but they also promote absorption of exudate in the later stages, and are particularly valuable in chronic inflammations. Great benefit is obtained by blistering old thickened ulcers, and by painting the chest with iodine to relieve pleuritic effusion. Frictions, besides their pressure effects, act as counterirritants. Frictions may relieve skin pain, and are associated with the application of stimulating liniments in the treatment of stiff joints. A mustard plaster is a valuable counterirritant in an acute deeply seated inflammation. Tincture of iodine is extensively used in chronic inflammation.

There is no more efficient method of relieving pleural effusion than by the application of a succession of blisters. Blisters are also used in the treatment of inflamed joints, pericarditis, pneumonic consolidation of the lung, acute and chronic rheumatism, etc.; and are applied back of the ears or at the nape of the neck in congestive coma or meningitis. A blister can be produced in a few minutes by soaking a bit of lint in chloroform, and after applying it to the surface, covering it with oiled silk or with a watch-glass. Equal parts of lard and ammonia will blister in five minutes. It is easier to blister with cantharidal collodion or blistering paper. Before applying a blister, shave the part if it be hairy; then grease the plaster with olive oil and apply it. Blistering plaster is left in place six hours in the case of an adult, but only two hours in the case of an old person or a child; the plaster is then removed, and if a blister has not formed, the part must be poulticed for a few hours. When a blister is obtained, open it with a needle which has been dipped in boiling water. If the surgeon wishes the blister to heal, it should be covered with a piece of lint smeared with cosmolin or with zinc ointment. If it is to be kept open for a time, cut away the stratum corneum and dress with cosmolin, each ounce of which contains six drops of nitric acid.

Pustulation can be effected with tartar-emetic ointment or with Vienna paste. Tartar-emetic ointment was formerly used on the scalp in meningitis. Vienna paste consists of 5 parts of caustic potash and 6 parts of lime made into a paste with alcohol. It is applied for five minutes, and is then washed off with vinegar.

The hot iron is the most powerful of counterirritants. It is chiefly used in chronic inflammation of joints, bone, and the spinal cord. The application is, of course, very painful, and it is best to give an anesthetic before using the cautery. A flat cautery iron may be used, or the round iron. The latter is known as the button or Corrigan's cautery. The iron is used at a white heat. One area or several may be seared. The cautery is drawn lightly two or three times over each spot we wish to burn. The object is to destroy only the superficial layers of the skin. After the cauterization is completed, lint wet

with iced water is applied for several hours to allay pain, and then hot antiseptic fomentations are used until the slough separates.

If we wish to prevent healing after separation of the slough, dress the sore with cosmolin, each ounce of which contains 6 drops of nitric acid. It is not wise to cauterize deeply directly over a superficial joint.

Constitutional Treatment of Inflammation.—Certain remedies are used in inflammation for their general or constitutional effects; these remedies are—(1) general bleeding; (2) arterial sedatives; (3) cathartics; (4) diaphoretics; (5) diuretics; (6) anodynes; (7) antipyretics; (8) emetics; (9) mercury and iodids; (10) stimulants; and (11) tonics.

General Bleeding, Venesection, or Phlebotomy.—Venesection is suited to the early stages of an acute inflammation in a young and robust subject. The indication for its employment is increased arterial tension, as shown by a strong, full, rapid, and incompressible pulse in a vigorous young patient. General blood-letting diminishes blood-pressure and increases the speed of the blood-current, thus amends stasis, absorbs exudate, and washes adherent corpuscles from the vessel-wall; furthermore, it reduces the whole amount of body blood and thus forces a greater rapidity of circulation, decreases the amount of fibrin and albumin, lowers the temperature, arrests cell-proliferation, and stops effusion.

This procedure was in former days so highly esteemed that it settled into a routine formula to be applied to every condition from yellow fever to dislocation. The terrible mortality of the cholera epidemics from 1830 to 1835 led practitioners to question the belief that bleeding was a general panacea, and from this doubt there was born in the next generation violent opposition to blood-letting in any disease. Like most reactions, opposition has gone too far, the pendulum of condemnation has swung beyond the line of truth and sense, and thus is universally neglected or broadly condemned a powerful and valuable resource. Many physicians of long experience have never seen a person bled; its performance is not demonstrated in most schools, and but few patients and families will permit it to be done. But when properly used it is occasionally beneficial. It is applicable, however, only to the young, strong, and robust, and not to the old, weak, or feeble. It is used for violent acute inflammations of important organs or tissues, and not for low inflammations or for slight affections of unimportant parts. It is used in the early, but not in the late, stages of an inflammation. It is used when the pulse is frequent, full, hard, and incompressible, but not when it is slow, small, soft, compressible, and irregular. It is used when the face is flushed, but not when it is pallid. It is not used in fat persons, drunkards, very nervous people, or the sufferers from adynamic, septic, or epidemic diseases. It is of value in some few cases of congestion of the lungs, pneumonitis, pleuritis, meningitis, prostatitis, cystitis, and other acute inflammatory conditions. It is particularly valuable when uremia exists or when there is distention of the right side of the heart. The method of bleeding is described on page 331.

After bleeding, the patient should be put on arterial sedatives, diuretics, diaphoretics, anodynes, and, if necessary, purgatives. A favorite mixture of Prof. S. D. Gross was the antimonial and saline, gr. xl of Epsom salt, gr. $\frac{1}{16}$ of tartar emetic, 2 drops of tincture of aconite, and 5j of sweet spirits of niter, in enough ginger syrup and water to make 3ss; given every four hours.

Arterial Sedatives.—Drugs of this character are of great use before stasis is pronounced; but if used after stasis is established they will increase it. If stasis exists it may be relieved by blood-letting, local or general, and then arterial sedatives can be given. Either local bleeding or venesection abolishes stasis and lowers tension, and arterial sedatives maintain the effect and hold the ground which is gained. The arterial sedatives employed are aconite, veratrum viride, gelsemium, and tartar emetic. These sedatives lessen the force and the frequency of the heart-beats, and thus slow and soften the pulse, and are suited to a robust person with an acute inflammation, but are not suited to a weak individual in an adynamic state.

Aconite is given in small doses, never in large amounts. One drop of the tincture in a little water is given every half hour until its effect is manifest on the pulse, when it may be given every two or three hours. Large doses of aconite produce pronounced depression, and are dangerous. Aconite lowers the temperature, slows the pulse, and produces diaphoresis.

Veratrum viride is a powerful agent to slow the pulse and to lower blood-pressure; it produces moisture of the skin, and often nausea. It is given in 1-drop doses of the tincture every half hour until its physiological effects are manifested, when the period between doses is extended to two or three hours. Ten drops of laudanum given a quarter of an hour before each dose of veratrum viride will prevent nausea.

Gelsemium is an arterial sedative highly approved by Bartholow. It is given in doses of 5 to 10 drops of the tincture every three or four hours.

Tartar emetic lowers arterial tension and lessens the pulse-rate. This drug is not generally employed; if it is used with the greatest care it is no better than some other agents, and if it is not so used it will cause dangerous depression. The dose is from gr. $\frac{1}{20}$ to gr. $\frac{1}{10}$ in water every three hours until the physiological effects are manifest.

Cathartics.—Purgation is of great value in inflammation. By it putrid material is removed from the intestine, fluid containing poisonous elements is drawn from the blood, and the liability to infection of the tissues is lessened. The administration of purgatives is, of course, not to be a routine procedure in inflammatory states. The bowels may be acting so freely that no cathartic is required. Treatment in an inflammation should be inaugurated, if constipation exists, by giving a cathartic. The tongue affords important indications as to the necessity for purgation. Castor oil can be given in capsules, or the juice of half a lemon is squeezed into a tumbler, 1 ounce of oil poured in, and the rest of the lemon is squeezed on top, thus making a not unpalatable mixture. Aloin, podophyllum, the salines, and calomel in 5- or 10-grain doses, followed by a saline, have their advocates. In peritonitis the salines are of unquestionable value, a teaspoonful of Epsom salt and a teaspoonful of Rochelle salt being given hourly until a movement occurs. In the course of inflammation, from time to time, if there be constipation, a coated tongue, and foulness of the breath, there should be ordered gr. j of calomel with gr. xxiv of bicarbonate of sodium, made into twelve powders, one being given every hour; if the bowels are not moved by the time the powders are all taken, a saline should be given. If a violent purgative effect is desired, as in meningitis, croton oil or elaterium may be ordered. If constipation is persistent, give fluid extract of cascara sagrada daily (20 to 40

drops), or a pill at night containing gr. $\frac{1}{4}$ of extract of belladonna, gr. $\frac{1}{4}$ of extract of nux vomica, gr. $\frac{1}{10}$ of aloin, gr. $\frac{1}{4}$ of extract of physostigma, and gtt. $\frac{1}{2}$ of oil of cajuput. Enemas or clysters may be used in some cases. A very useful enema is composed of f $\overline{5}$ j of oil of turpentine, f $\overline{5}$ ss of olive oil, f $\overline{5}$ ss of mucilage of acacia, in f $\overline{5}$ x of water. Soapsuds and vinegar in equal parts make a serviceable clyster. A combination of oil of turpentine, castor oil, the yolk of an egg, and water can be used. Asafetida, gr. xxx to the yolk of one egg, makes a good enema to amend flatulence.

Diaphoretics.—These agents are very useful. A profuse sweat removes much toxic material from the blood and in the beginning of an acute inflammation, such as tonsillitis, may abort the disease. Dover's powder is commonly used, but pilocarpin is preferred by some. Camphor in doses of from 5 to 10 grains is diaphoretic, and so are antimony and ipecac. Acetate and citrate of ammonium, opium, alcohol, hot drinks, heat to the surface (baths, hot bricks, hot-water bags), serpentaria, and guaiac are diaphoretic agents.

Diuretics.—Diuretics are useful in fevers when the urine is scanty and high-colored, and are valuable aids in removing serous effusions and other exudates. Among the diuretics may be mentioned calomel in repeated large doses, cocain, alcohol, digitalis, the nitrites, squill, turpentine, copaiba, and cantharides. The liquor potassæ and the acetate of potassium are the best agents to increase the solids in the urine. The liquor potassii citratis in doses of f $\overline{5}$ j to f $\overline{5}$ iv is efficient. Large draughts of water wash out the kidneys. If the heart is weak, citrate of caffein is a good stimulant diuretic, and hot coffee is very serviceable in promoting the secretion of urine. The injection of hot salt solution into the rectum and under the skin favors diuresis, and the intravenous infusion of salt solution is a very powerful diuretic. The application of heat to the loins promotes the secretion of urine. Sodio-theobromin salicylate (diuretin) is an uncertain but often valuable diuretic, in doses of gr. x every two or three hours.

Anodynes and Hypnotics.—Drugs may be required to allay pain or procure sleep. Dover's powder, besides being diaphoretic, is anodyne. Opium acts well after bleeding or purgation. If it causes nausea, it should be preceded one hour by the administration of gr. xxx of bromid of potassium. Opium is used by the mouth, by the rectum, or hypodermatically. It is used when there is pain, but its use is not to be long persisted in if it can be avoided. It is given in doses measured purely by the necessities of the case. If opium disagrees, try the combination of morphin with atropin. After an operation antipyrin or phenacetin will often quiet pain and secure sleep. When a person feels "so tired he can't sleep," alcohol in the form of whiskey or brandy must be given. Sleeplessness not due to pain is met by chloral, trional, the bromids, or sulphonal. Chloral is dangerous in conditions of weak heart or exhaustion. Bromids must be given in large doses to be efficient. Sulphonal must be given about four or five hours before sleep is expected, in doses of from gr. x to gr. xx in hot milk or hot mint-water. Trional is safe and very satisfactory. It is given in doses of gr. xv to gr. xxv in hot water.

Antipyretics.—Arterial sedatives, diaphoretics, and purgatives lower temperature, and have previously been alluded to (page 85). There are two great classes of febrifuges—those which lessen heat-production and those which increase heat-elimination. In the first group we find quinin, salicylic

acid and the salicylates, kairin, alcohol, antimony, aconite, digitalis, cupping, and bleeding. In the second group we find alcohol, nitrous ether, antipyrin, acetanilid, phenacetin, opium, ipecac, cold to the surface, and cold drinks. In surgical inflammations it is rarely necessary to employ heroic means to lower temperature. The use of such an agent as antipyrin is contraindicated in the weak and adynamic, and it is never to be thought of as a means of lowering temperature unless the latter goes above 103° F. Quinin, in doses of gr. xx to gr. xxx given at 4 P. M., may prevent an evening rise; salol or salicin can be given during the day. Inunctions of 30 minims of guaiacol lower the temperature in tuberculous conditions and in septic fevers. These inunctions are made upon the abdomen, and often produce surprising results. Dujardin-Beaumetz maintained that fever is a condition in which the animal organism is endeavoring to oxidize and render inert certain poisonous material, and that antipyretic drugs lessen oxidation and actually make the patient worse. This view is in accordance with the experience of a number of surgeons. It is a suggestive fact that bacteria are said to multiply more rapidly when kept at about the normal body-temperature than when kept at fever heat (102° F., or more). The mere discomfort of fever may be much mitigated by antipyretic drugs, but the fever process is not benefited by them.

Emetics.—Emetics may do good when the patient suffers from a parched, coated tongue, a dry and hot skin, nausea, and gastric oppression, but it is very rarely in these days that we employ them. There can be used \mathfrak{z} j of alum in molasses, gr. xx of sulphate of zinc, or a tablespoonful of mustard and a teaspoonful of salt given in warm water and followed by large draughts of warm water. Ipecac in a dose of gr. xx can be employed. The emetic dose of tartar emetic is gr. ij, but it is too depressant a drug to trifle with. The sulphuret of antimony in doses of from 1 to 5 grains is safe. Apomorphin hypodermatically, in a dose of from gr. $\frac{1}{16}$ to gr. $\frac{1}{8}$, will act in five minutes. Emetics are valuable in inflammatory conditions of the air-passages, but their use is contraindicated in diseases of the heart, brain, and bowels, in hernia, in dislocations, in fractures, and in aneurysms.

Mercury and the Iodids.—Mercury is an alterative—that is, an agent which favorably affects body nutrition without causing any recognizable change in the fluids or the solids of the body. Mercury lessens blood plasticity, hinders the exudation of liquor sanguinis—thus furnishing less food to the cells in the perivascular tissues—and retards cell-proliferation. Further, by a stimulant action on the absorbents it promotes the breaking up of an existing inflammatory exudation, and hence limits damage from excess of new formation. The time at which mercury is best given is when violent symptoms have abated, the guides being a reduced temperature and a moist skin. Mercury is often given in conjunction with the local use of sorbefacients (ichthyol, or mercurial ointment). When possible, the administration of mercury is associated with compression of the inflamed part. It is sometimes given until the gums are slightly touched, but it is not given to the point of salivation. When the breath becomes offensive and the gums tender on snapping the teeth, or when griping and diarrhea begin, the dose should be reduced, or the drug should be stopped (see Ptyalism). In iritis mercury is used to get rid of the plastic effusion which is causing pupillary fixation and opacity. In keratitis the gums should be touched *slightly*. In orchitis, after

the subsidence of the acute symptoms, mercury should be employed. In pericarditis, meningitis, and in many chronic and lingering, and in all syphilitic inflammations, this drug can be used.

Some persons will be salivated with very minute doses of mercury, either because of idiosyncrasy or previous saturation. Others can take enormous doses without any appreciable constitutional effect. The action of mercurials can be favored by a combination with ipecac or with tartar emetic.

In giving mercury, if a prompt effect is desired, give gr. iij of calomel every three hours until a metallic taste is noted in the mouth. If the case is not so urgent, gray powder is a good combination. Children are given calomel and sugar or mercury and chalk. If it is desired to give the drug for some time, corrosive sublimate is a suitable form, and small doses will actually increase the number of red blood-corpuscles. Corrosive sublimate is to be given alone or combined only with iodid of potassium. The green iodid of mercury is a drug suitable for prolonged administration. In the prolonged use of mercury it will often be necessary to give at the same time a little opium to prevent diarrhea and griping. A rapid effect can be obtained by rubbing daily with a gloved hand \mathfrak{z} j of the oleate of mercury or \mathfrak{ss} of the ointment into the groins, the axillæ, or the inside of the thighs. Suppositories of mercurial ointment induce rapid ptialism. Hypodermatic injections of corrosive sublimate or gray oil may be used, and must be thrown deeply into the muscles of the buttock or back. Old people, those who are exhausted, anemic, and broken down, and the tuberculous bear mercury badly. If it be given to them at all, it must only be in small amounts and for a brief time.

Alkaline iodids are useful in removing the products of inflammation; they can be given for a long time, and admirably supplement mercurials. Iodid of potassium can be prescribed in combination with corrosive sublimate as follows:

R. Hydrarg. chlor. corros., gr. ij;
Potass. iodidi, \mathfrak{z} v et \mathfrak{z} j;
Syr. sarsaparillæ comp., q. s. ad f \mathfrak{z} viiij.—M.
Sig.—f \mathfrak{z} ij, in water, after meals.

Iodid of potassium, well diluted, is given on a full stomach; it is never given concentrated or before meals. A convenient mode of administration is to procure a concentrated solution of the iodid of potassium, remembering that every drop equals about gr. j of the drug, and give as many drops as may be desired in half a glass of water after meals. If the medicine disagrees, add to each dose, after it is put in water, \mathfrak{z} j of the aromatic spirit of ammonia. Extract of licorice is a good vehicle for the iodid. If the mixture in water disagrees, the drug should be given in milk. Capsules are satisfactory, but a drink of water should be taken just before and again just after taking a capsule, to protect the stomach from the concentrated drug. Iodid of sodium may agree when iodid of potassium does not. When the iodids disagree they produce iodism. The first indications of iodism are a bad taste in the mouth, running of the eyes and nose, and sneezing, followed by a feeling of exhaustion, absolute loss of appetite, nausea, tremor, and skin eruptions (acne, hemorrhages, blebs, hydroa, etc.). If iodism occurs, stop the drug and give the patient Fowler's solution in increasing doses, laxatives, diuretic waters, and also nutritious food, and stimulants if depression is great. Sometimes belladonna does good in obstinate cutaneous disorders induced by the iodids.

Remedies Directed against Special Morbid States.—If inflammation is associated with rheumatism, gout, scurvy, syphilis, tuberculosis, or any other constitutional disease or predisposition, appropriate treatment should be instituted to control the disease or combat the predisposition, and at the same time the area of inflammation must be locally treated. Syphilis is treated by the internal use of mercury and in some cases the iodids are also given; scurvy, by vegetable juices and potash salts; rheumatism, by the alkalies or salicylates; gout, by colchicum or piperazin; tuberculosis, by the fats, tonics, and an open-air life.

Alcohol.—The use of *alcoholic stimulants* is called for by conditions rather than by diseases, being indicated by the state of the patient rather than by the name of the malady. For a brief acute inflammation in a robust young person alcohol is not needed; but all who are weak or exhausted, be they young or old, all who are aged, those who are accustomed to alcoholic beverages, those who have high temperatures or failure of circulation, and those who labor under septic inflammations or adynamic processes require alcohol, and it should be given with a free hand. In an acute malady, a feeble, compressible, rapid, or irregular pulse, and great weakness of the first sound of the heart are indications that alcohol is required. Low, muttering delirium is a strong indication for stimulation. There is no *dose* of alcohol for these states; it is given for its effect. Two ounces of brandy or whiskey may be needed in a day, or perhaps twenty ounces. If the breath of the patient smells strongly of the alcohol, he is getting too much. If delirium increases after each dose, alcohol is doing harm. Alcohol is contraindicated in acute meningitis. In acute illness use whiskey, brandy, champagne, or alcohol and water. During convalescence there may be used a little port, claret, or sherry wine, or malt liquor. These agents will promote appetite, digestion, and sleep.

Strychnin is a very valuable stimulant. It can be given in doses of gr. $\frac{1}{30}$ to gr. $\frac{1}{20}$ three times a day.

Tonics.—The use of tonics is indicated during convalescence from acute and throughout the course of chronic inflammations. There may be used iron, quinin, and strychnin in the form of elixir; iron alone, as in the tincture of the chlorid; quinin in tonic doses (gr. vj to gr. viij daily); or Fowler's solution of arsenic. An excellent pill consists of—

R. Acid. arsenos., gr. j;
 Strychnini, gr. ss;
 Quinini, gr. xlvij;
 Ferri redact., gr. vj.—M.

Ft. in pil. No. xxiv.

Sig.—One after each meal.

Bitter tonics before meals improve the appetite. One of the best of tonics is tincture of nux vomica in gradually increasing doses.

Antiphlogistic Regimen.—This term comprises the necessary directions relating to diet, ventilation, cleanliness, etc.

Diet.—When, in the early stages of an acute inflammation, the patient cannot eat, there must be administered a cathartic before food is given. Nausea is combated with calomel and soda, drop-doses of a 6 per cent. solution of cocain, iced champagne, iced brandy, chloroform-water, hot water, cracked ice, or the application of counterirritation to the epigastric region.

When the process is depressive from the start, and in any case after the earliest stage, feeding is of vital moment. The great tissue-waste calls for large quantities of nutritive material, but the impaired digestion demands that the food shall be easily assimilable; hence it is taken in liquid form, small quantities being frequently given. Milk contains all the elements required by the body, and is the food of foods. If it disagrees, it should be boiled and mixed with lime-water, or to each dose an equal amount of Vichy or soda-water may be added. Peptonized milk is a valuable agent. One part of milk, 2 parts of cream, and 2 parts of lime-water make a nutritious and digestible mixture. Milk punch is largely used. Whey may be used when plain milk cannot be taken. Eggs are highly nutritious, but are apt to disturb the stomach; they may be given as egg-nog, or simply soft-boiled, or the yolk can be beaten up in a cup of tea. When considerable nausea exists, the yolk of an egg may be added to 5j of lemon-juice and 5ij of sugar, the glass being filled with carbonated water. Beef tea is certainly a stimulant, but its food powers are questionable. It is prepared by cutting up one pound of lean beef, adding to it a quart of water, and then simmering, but not boiling, down to a pint, finally filtering and skimming the liquid. The dose is a wineglassful seasoned to taste. Meat-juice, obtained by squeezing partly cooked meat with a lemon squeezer, is extremely nutritious. Liquid-beef peptonoids are both agreeable and nutritious; they are given in doses of 5ss to 5j. Clam-juice is palatable and digestible. When nothing else will stay on the stomach koumiss will often be retained. This fermented milk is nutritious, stimulant, and very useful. Coffee is a valuable stimulant in febrile conditions. If the stomach retains no food, the patient must be fed entirely by the rectum. If the stomach rejects most of the food swallowed, mouth feeding must be supplemented by nutritive rectal enemata. When the sufferer feels able to eat a little, any good soup, strained and skimmed, should be ordered. As the patient gets better he may be fed on sweetbreads, chops, oysters, etc., until he gradually reaches ordinary diet.

The *temperature* should be taken at regular intervals, and the condition of the gastro-intestinal tract should be observed. The *urine* must be examined at intervals, and the daily amount passed must be known. If insufficient urine is being passed, increase the amount of fluid, particularly of water, given by the mouth. If the urine is scanty and the patient is nauseated by drinking water, give enemata of hot saline fluid or employ hypodermoclysis. The *pulse* and *heart* must be frequently observed, and cardiac weakness must be combated by suitable stimulants.

Ventilation and Cleanliness.—The ventilation of the apartment is of the greatest importance. Every day the windows should be opened widely for a time, the patient, of course, being protected. When the windows are open the air of a room can be quickly changed by swinging the door to and fro. A constant access of fresh air must be secured, and the temperature kept as near as possible to 68° F. The sick man must be cleaned and be sponged off with alcohol and water every day if high fever exists. It is important that the bed-clothing be clean and that the sheet be unwrinkled, as otherwise bed-sores may form.

Treatment of Chronic Inflammation.—The subject of chronic inflammation has been referred to previously. The local treatment comprises rest,

relaxation, elevation, counterirritation, massage, passive movements, the douche, the application of sorbefacients, the use of compression, and incision. The patient must be placed under proper hygienic and climatic conditions; the diet must be judiciously regulated; drugs are given symptomatically or to combat some constitutional tendency or disease (see articles upon special regions and diseases).